Game Theory and Applications
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Preface

A Robust Control Approach to Option Pricing: the Uniqueness Theorem 1–18
P. Bernhard, N. El Farouq

Abstract

We prove the missing uniqueness theorem which makes our probability-free theory of option pricing in the interval market model, essentially complete.

Existence and Uniqueness of Nash Equilibria in a Simple Lanchester Model of the Impact of Customer Churn 19–26
J. M. Binner, L. R. Fletcher, V. Kolokoltsov

Abstract

We model the impact of customer churn (turnover) on player payoffs in a duopolistic market, distinguishing between loyal and non-loyal customers, using a Lanchester-type model. We ensure that the underlying equations always have a feasible solution, which cannot be taken for granted, and prove the existence and uniqueness of Nash equilibria. We find algebraic conditions for a Nash equilibrium and then apply the Brouwer Fixed Point Theorem to show that these conditions can be satisfied. Expressing these conditions as equations in which one side is an increasing function of marketing effectiveness and the other side is decreasing proves that there can be no more than one Nash equilibrium.

The Game-Theoretical Model of Selection Services in Company with Various Ordering Schemes 27–44
V. M. Bure, A. A. Sergeeva

Abstract

In this paper we consider the cases of different number of ordering schemes in company which provide service for customers. The game-theoretic model of choosing order service in each case is constructed. The model is a n-person game with perfect information. We find equilibrium strategies for clients of different cases the number of ordering schemes in the company. The existence of these equilibria is proved.

Numerical Approximation of Nash Equilibria for a Class of Non-Cooperative Differential Games 45–58
S. Cacace, E. Cristiani, M. Falcone

Abstract

In this paper we propose a numerical method to obtain an approximation of Nash equilibria for m-players non-cooperative games with a special structure. We consider the infinite horizon problem in a case which leads to a system of m Hamilton-Jacobi equations. The numerical method is based on the Dynamic Programming Principle for every equation and on a global fixed point iteration. We present the numerical solutions of some two-player games in one and two dimensions. The paper has an experimental nature, but some features and properties of the approximation scheme are discussed.

Public Goods in Networks: A Statistical Mechanics Approach 59–80
L. Dall'Asta, P. Pin, A. Ramezanpour

Abstract

The problem of multiple Nash equilibria in games of strategic substitutes on networks is studied. We consider a general model of public goods provision on network, and analyze in detail the properties of Nash equilibria with particular attention for the subset of equilibria that optimize some global quantities (*optimal equilibria*) and to those that are robust to small perturbations (*stable equilibria*). We conclude that finding good approximate optimal equilibria is not that difficult, and we describe the performances of different algorithms. On the other hand, finding stable equilibria is extremely difficult, by means of naive best-response dynamics as well as using advanced message-passing algorithms. This is a consequence of the intrinsically different spatial organization of the two sets of equilibria.

Network Congestion, Braess Paradox and Urban Expressway System 81–100
B. Dong

Abstract

The "Braess Paradox" persists in transportation networks. This paper studies the congestion properties in networks constituted by a set of circular and diffusive expressways. We use a model with a single origin/multiple destination (E-net) to depict the evening rush hour, and one destination/multiple origin (M-net) to depict the morning rush hour. Conditions for efficient equilibrium in this model are obtained. Policy recommendations in regard to capacity handicapping/enlargement of key roads and differential parking charges are given.

Game-theoretical model of service quality choice: Portuguese mobile service market 101–118
M. A. Gladkova, N. A. Zenkevich, A. A. Sorokina

Abstract

In this paper game-theoretical model of quality level choice under competition is suggested in order to define optimal quality strategies of mobile operators. Suppose that five firms provide homogeneous services differentiated by quality on the industrial market. The game-theoretical model is presented as dynamic game. The strong Nash equilibrium in the investigated game was obtained in the explicit form which allowed us to evaluate prices, companies market shares and revenues in the equilibrium. The survey was conducted in St. Petersburg and defined consumer preferences and satisfaction with mobile service. The survey and game-theoretical analysis of Portuguese industrial market allowed finding current and equilibrium service quality levels. The results showed that all operators should increase service quality. Following the equilibrium quality strategies, mobile operators may achieve the increase of the average consumers monthly expenses. Market shares were also analyzed and it was shown how the situation changes when applying game-theoretical results for mobile operators of Portugal.

Paul Samuelson's Critique and Equilibriums Concepts in Evolutionary Game Theory 119–136
R. Joosteny

Abstract

We present two new evolutionary equilibria, the truly evolutionarily stable state (*TESS*) and the generalized evolutionarily stable equilibrium (*GESE*). The latter generalizes the evolutionarily stable equilibrium (*ESE*) of Joosten [1996]. A *GESE* attracts all nearby trajectories monotonically, i.e., the distance to equilibrium decreases steadily in time. The former generalizes the evolutionarily stable strategy (*ESS*) of Maynard Smith & Price [1973]. The *TESS* attracts nearby trajectories too, but the dynamics' behavior must be similar to that of the replicator dynamics near an *ESS*.

Both notions immediately imply asymptotical stability for the dynamics at hand. We consider this the relevant and conceptually right approach in defining evolutionary equilibria, rather than defining a static equilibrium notion and search for appropriate dynamics guaranteeing its dynamic stability.

Price Stackelberg Competition and Capacity Constrains 137–144
L. Meng, C. Han, J. Wang

Abstract

Two identical firms compete with price as the strategic variable in a homogeneous product duopoly game and in which the firms are limited by capacity constraints. An efficient rationing rule is adopted. We show when the firms are symmetric, there is a unique subgame perfect Nash equilibrium (SPNE), where either both firms sell at capacity and do equally well, or else there is a second mover advantage. We analyze an asymmetric case and give the equilibrium.

An Inter-group Conflict Model Integrating Perceptions of Threat and Vested Interest: Extending Rational Choice to Incorporate Psychological Dynamics 145–164
G. Pierce, C. Boulay, M. Malyutov

Abstract

The prevalence of inter-group conflict throughout the world over the past century has been widely examined from a broad range of substantive perspectives. Among the factors that have received less attention in terms of their potential role in inter-group conflicts are the psychological dynamics associated with changes in the political attitudes of the populations of groups in conflict and also those of their leaders as well as factors relating to the perceived success of conflict related strategy. The present analysis attempts to integrate the potential psychological effects of threat into a model of inter-group conflict that also incorporates actors vested interest in conflict oriented policies and also the actors perception that such policies will be successful. In the considered model, the immediate psychological effects of an external threat may be very similar for both the general public and political leaders. Moreover such reactions are expected to be in line with at least some of the responses hypothesized from mortality salience theory. Other types of

reactions to an external threat may be quite different for the general public versus their political leaders. The analysis attempts to incorporate into a game theoretic framework, the likely impact of perceived and/or actual external threats on internal inter-group political dynamics, and the potential consequence of these responses on the informal and formal strategies selected to deal with perceived/actual threats.

Product Differentiation in the Presence of Social Interactions of Consumers 165–176
F. P. A. Prado

Abstract

We present a dynamic game of location-price competition between two firms. Differently from other Hotelling's type models, we assume that consumers are positively influenced by the product choices of other consumers.

Our model suggests the existence of two types of oligopolies: one characterized by agglomerations of players and another characterized by separations of them. This result generalizes the standard result of location-price competition as in d'Appremont et al. (1979). It provides insights into product differentiation behaviors in cases whereby consumers enjoy consuming products in the company of others (Becker, 1991) and decide in small groups where to consume from.

A Class of Differential Games with Random Terminal Time 177–192
E. V. Shevkoplyas , S. Yu. Kostyunin

Abstract

In the paper, a class of differential games is considered where the terminal time of the game is treated as a random variable. For this game, the simplest form of the expected integral payoff of the players is found and the sufficient conditions for simplification of the integral payoff are formulated. The obtained simplified form is used it to derive the Hamilton-Jacobi-Bellman equation for the game with random terminal time. Finally, a game-theoretical model of pollution control is considered. For this particular example, both non-cooperative and cooperative forms of the game are investigated.

The Present and Future of Game Theory 193–208
M. Shubik

Abstract

A broad nontechnical coverage of many of the developments in game theory since the 1950s is given together with some comments on important open problems and where some of the developments may take place. The nearly 90 references given serve only as a minimal guide to the many thousands of books and articles that have been written. The purpose here is to present a broad brush picture of the many areas of study and application that have come into being. The use of deep techniques flourishes best when it stays in touch with application. There is a vital symbiotic relationship between good theory and practice. The breakneck speed of development of game theory calls for an appreciation of both the many realities of conflict, coordination and cooperation and the abstract investigation of all of them.